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RECENT DISCOVERIES IN NORTHEASTERN NICARAGUA: GRANITE HILLS, MOUTONNÉD RIDGES AND GOLD-CONTAINING LODES OR REEFS, AND LEADS OR PLACER MINES.

BY J. CRAWFORD, RIO WANQUE OR COCO, AT SAN RAMON, NICARAGUA.

DURING the past year, commencing August, 1892, ten months of nearly continuous exploration have been spent by the author over an area of some 10,000 to 12,000 square miles in the uninhabited wilderness and jungle that cover a large part of northeastern Nicaragua, examining the geology, minerology, and flora existing in great attractiveness and variety in that part of the country. Among the numerous interesting features and peculiarities discovered or noted that are worthy, from both a scientific and economical point of view, of a more special description than was given of them in my paper, "Hydrographic Area of the Rio Waukey, or Coco-Nicaragua," published in *Science*, in April, 1893, are the following:

(a) The granite outbursts exposed on the tops of oval-shaped *Cerros* or mountains, and which also form the *Cima del Cerro* and longer axis of long, high, mountain ridges.

(b) The numerous moutonnéd ridges and lateral and terminal moraines, in series that evidence the former existence of a glacial epoch which covered an area of several thousand square miles in Nicaragua with a flow of glacial ice.

(c) The erosion-sculptured *Cerros* that intervene between the granite hills and moutonnéd ridges, composed of debris denuded from both the nearby granite mountains and materials from mountain ranges found further to the southward.

(d) The reefs or lodes (many of them auriferous) and dykes (of diorite) in which auriferous quartz veins are discovered piercing the mountains and ridges parallel to the length of the series of the system; and also the Post-Pliocene leads of drifts of gravels and boulders. Gold is found exposed in the banks at sides of streams, that appear to extend through the erosion-sculptured hills near their base, and also the alluvial leads, drifts of gravels, gold, etc., found in the channels of the creeks and in strata in the lower parts of valleys.

(e) The composition and fertility or non-fertility of the soil and its fitness, in places, for the vigorous growth of certain kinds of trees or plants, also the peculiar formation where groves of some kinds of valuable trees were found growing to large dimensions.

(f) The apparent geological history of the granite hills, dykes, reefs or lodes, moutonnéd ridges, erosion-formed ridges, and of the leads or placer mines.

The region in northeastern Nicaragua chosen for description in this paper as typical of a few others in that part of the country is a wilderness unoccupied by man[1]; and although this locality is a part of Nicaragua, neither the government nor the citizens of that country have even a vague conception of its importance and its truly great undeveloped wealth in valuable minerals and metals, timber, and agricultural lands. The centre of this chosen locality is about longitude 85° W. (from Greenwich) and latitude 14° N., and embraces the headwaters of Nawawass, Wilson, Loccus, Umbra, Waspoopoo, Moorawass, Sangsang and Daka Creeks, and Wasspook River, confluents to Rio Waukey, or Coco River, and also the line of *Cerros*, about sixty miles long, just south of the Wasspook River.

The granite masses appear to be in two parallel lines of elevation, but connected together as one mass and composed of rock of the same mineral composition, usually amphibole, syenites (with and without quartz), and also protogene and plagioclose varieties appear most numerous. The cooling has permitted the crystallization of the minerals so similarly at about the same depth from the surface (isogeothermal zone) in each line of ridges, as to indicate that the two exposed lines were of the same mass and lowering in temperature at the same rate. The granite has been exposed by erosion, and the hills, also, have been eroded deeply at many places, and the rocks have, at several places observed, become disintegrated and decomposed, *in situ*, to depths of five to twenty feet. The exposed granites are in series of spurs and ridges that extend northeastwardly for about ninety miles from the Barbar Mountains (at the southeastern termination of the Matagalpa system of mountains), and form an angle of about 120° with the southeasterly and northwesterly direction of that mountain system, which is composed largely of Archean and Silurian era rocks.

The northeastern termination of these granite spurs and ridges is near to the confluence of the Rios Wasspook and Wauque, at a distance of about one hundred miles west from the Carribbean Sea, on the eastern coast of Nicaragua, and about the same distance south from that sea on the northern coast of Nicaragua. The forces causing this upheaval of granite appear also to have fissured the superimposed and adjacent systems of rocks for many miles[2]. These fissures are now filled by deposition of minerals and metals from hot solutions, and are now reefs or lodes, containing quartz, gold, metallic ores, and other minerals. Near the northern termination of these granite ridges were found patches, of varying size, of auriferous sands, gravels, clays, and boulders—detritus transported by water from the denuded granite hills and from ranges in the Matagalpa system of mountains. These deposits of detritus increase in size northwardly, until covered northwardly by the sands and mud composing the delta of the Rio Wauque; and on the west the deposits of detritus were in large quantities, and subsequently have been sculptured by erosion into hills and ridges; also found resting in small areas on the granite ridges are boulders in size from a few pounds to over two hundred pounds each, of varieties of bluish glaucophanyte, or hypers-

[1] Recently two or three Latin-Americans have, in a crude way, simulated placer-mining work in one or two of the mineral localities. They appear hopeful and cheerful.

[2] It is very difficult, frequently impossible, to trace the extent of the outcropping of lodes or reefs, and even of dykes, in this wilderness of dense growth of trees, vines and plants and a deep soil.

thenyte, or augyte, or trachyte rocks, that appear thickly sprinkled with pyrites and magnetic and titanic iron ores; these boulders were weathered toward their centres from one to three inches, and were found to be auriferous—in some instances, highly so; they differ in composition and color from the hornblende and orthoclase granite-mass forming the axis and serrated ridges of the hills, also from the boulders mixed with the patches of clay, sands, gravels, and boulders that are found to the southward on these granite hills and ridges. This filling up of former existing valleys with the materials worn off, in part, from the granite ridges, evidences a subsidence in that locality at the time, and this evidence is supported by the existence, to the north of the granite hills and between them and the Wauque, or Coco, River, of a disconnected line of limestone; on one depression of this limestone a deposit of the auriferous clays, sands, gravels, and boulders was found. The eroding into hills and valleys, as they at present appear, composed of the mass of detritus of disintegrated granites, etc., is evidence of a subsequent elevation of that entire region and the completing of one oscillation of subsidence and of re-elevation there.

The moutonnéd ridges extend for about sixty miles in a series of parallel oblong ridges northeastwardly from near the base of the tall Barbar and Peña Blanca Mountains, that at present have an altitude of over 7,000 feet above the Caribbean Sea. One of the projecting lines of moraines extends further northward, and is about ninety miles long until it terminates at a dyke, on whose sides auriferous gravels are found, in which the Rio Wauque has cut its channel at San Ramon.

This system of moutonnéd ridges extends to a width eastward and westward of about twenty-five miles, and has at present an altitude above the creeks at its base of from 70 to 400 feet. They were found to be composed most generally of unstratified clays, sands, gravels, and boulders; occasionally, however, these materials are partly stratified and partly assorted. The enclosed boulders are of various sizes, from ten pounds to several tons weight, and are usually angular or sub-angular, becoming oblong and oval as the series of moutonnéd ridges extend northward, *i. e.*, towards the Wauque River, and are composed most generally of fragments of auriferous quartz, granites, syenites, hornblendic feldspatic rocks.

These moutonnéd ridges have been denuded and eroded by the very energetic and potent meteorological forces in this locality, until numerous large boulders have been displaced and lie on the sides and at the base of the ridges; also numerous gulleys score deeply the sides of these ridges, and deep ravines or channels of the flowing creeks separate many of them from each other. These moutonnéd ridges are unquestionable evidences of a glacial epoch and of a long-continued glacial flow *at this low parallel*—only 14° north from the equator[3]—which covered quite a large part of the present existing narrow divide of land (containing about 48,000 square miles) between the Pacific Ocean and the Caribbean Sea. Adjoining the granite hills on the northward and northwestward, often between the moutonnéd and the granite ridges, are a number of erosion-sculptured hills that have been carved out by the draining forces attending the elevation of lands in that locality, and evidence that elevation, and subsequently by meteoric forces. These hills of erosion are composed of the detritus of rocks transported by water from the southeastern ending of the Matagalpa system of mountains (a distance of seventy to eighty miles southwest), and of materials eroded from the adjoining and nearby series of granite hills; the materials composing them have been cemented and concreted into semi-hard rocks and conglomerate masses of clastic rocks. The altitude above the Caribbean Sea of many of these granite ridges, erosion-formed *Cerros* and moutonnéd ridges, is from 1,000 to 3,500 feet; all are covered with a dense growth of large trees, or, in some places on the erosion-formed ridges, covered with a jungle of trees, bamboos, vines, and other vegetation.

The reefs, or lodes, strike east of north and west of south, parallel to the long axis of the ridges and mountains, and those discovered usually dip at an angle of about 120° south. They are from 6 to 30 inches wide, and usually appear to be rich in gold and in metallic sulphides and arsenides. The reefs at the granite ridges are parallel with those ridges, and found at the contact between the granite and superimposed rocks (though some appear to be in the granite) as principal lodes, from which extend at various angles into the adjacent erosion-carved *Cerros* many fissures containing the oxide of metals, gold, sulphides, etc. Some few of these fissures appear to continue northwardly into the moutonnéd ridges; but this was not verified, because of the deep soil and dense undergrowth that covers the surface of the hills and valleys at that locality. The reefs parallel with the granite ridges extend southwestwardly to near the Barbar Mountains, where they appear to form an obtuse angle with the auriferous reefs, or lodes, that extend (southeast and northwest across Nicaragua) along the foothills of the Matagalpa system of mountains, from the Caribbean Sea to the Pacific Ocean. In the granite hills were discovered two large deposits of iron ores, limonite and hematite, and one deposit of manganese ore, the black di-oxide pyrolusite; also graphite and some tin sulphide, stannite, whether in paying quantities or not, *i. e.*, profitable to mining, has not been determined satisfactorily, because they were found but recently, this year, 1893, in an uninhabited wilderness; they are, however, in a thoroughly mineralized locality. The auriferous reefs are of the Dioritic gold-evolved era (as classified by David Forbes, F. R. S., in his paper "On the Geological Epoch at Which Gold Has Made Its Appearance in the Crust of the earth"),[4] and appear at the surface often where many greenstone rocks were discovered.

The auriferous placer deposits or leads of clays, gravels, sands, gold, and boulders are of different geological epochs, viz.: the strata of partly-cemented auriferous drifts of sands, gravels, etc., exposed in patches, small to several acres, at the sides near the base of the erosion-formed hills and appearing to pass through those hills, and also found in the upper valleys at varying depths beneath the surface and at many places exposed in the banks along the sides of the creeks. These leads of gravel drifts are from 8 to 20 inches thick, and although few masses of gold visible to the unaided eye were observed in them, yet when they had been washed out from a pan there were frequently left in the pan particles, grains, and small nodules of gold, or occasionally laminated small masses of gold of angular, sub-angular, and oval forms. These are "alluvial drifts," or gravel beds, formed during the latter part, I am inclined to believe, of the Champlain epoch, and usually contain only a small per cent of sub-angular and partly rounded quartz. The gold found in them is in rather coarse grains and particles, as described, and evidently derived from three sources:

(a) The auriferous reefs that traverse that part of the country, and—

(b) From the deeply disintegrated granite masses, and—

(c) From the disrupted masses of quartz, pyrites, etc.,

[3] At latitude 12° 20' north from the equator similar moutonned ridges and glacial epoch moraines were discovered on the south side of the southeastern termination of the Matagalpa system of mountain ranges, and were examined by the author of this paper in 1890, and reported on to the British Association for the Advancement of Science, the American Association for the Advancement of Science, and officially to the Government of Nicaragua.

[4] See London Geological Magazine, III., p. 385—7.

that once were enclosed in the moutonnéd ridges, and subsequently eroded therefrom. The gold is believed to be in quantity sufficient to be profitable to mining operations, especially because the mining could be done economically by water, which is convenient, abundant, and has a rapid fall or descent in the nearby creeks.

The alluvial beds of auriferous clays, sands, gravels, and small boulders that are found in the beds of some of the gulches and in the channels of some of the present system of creeks are often partly cemented by hydrous oxide of iron in some places and by silica at other localities. These deposits were commenced, I am persuaded, during the Terrace epoch, and, in some places, are apparently quite rich in gold of rough, semi-angular pieces and in rounded particles; yet some of the particles of gold in the small creeks or nearby dry gulches appear so angular and undisturbed at their edges as to impress one with the opinion that they have increased in size, "grown," where they are discovered by additions from passing solutions containing gold; the chief sources, however, of the gold found in these creeks are the same as those named under the head of reefs or lodes, with additions of gold from the older leads above described found in the upper, and apparently passing through the erosion-formed hills and from accretions of gold deposited from passing auriferous solutions. The bedrock in some of the creeks is an iron-cemented arenaceous argillyte resting on a bed of partly cemented boulders, sands and clays which appear, at one place discovered, probably in the entire locality, to rest on strata of auriferous conglomerates or breccia and this on an auriferous gravel superimposed on a bedrock of metamorphosed shale or slate.

Geological history. We found several obstacles intervening to prevent, at present, that careful examination necessary to determine the geological epoch, when these granite ridges were upheaved and when thereafter they were exposed by the denudation of superimposed strata; during what epoch the regional elevation occurred and the erosion-sculptured hills in that region were formed; from what rocks or sources came the gold found now in the reefs or lodes traversing, longitudinally, the mountains and ridges.

One obstacle is that no ravines or cañons were discovered that deeply enough expose the strata toward the centre of the mountains or ridges.

Other obstacles are, the very deep disintegration, in situ, of the exposed rocks and the deep soil covering the surface and also the dense vegetation, frequently a jungle difficult to cut a pathway through, covering in matted masses even the nearly perpendicular sides of ravines; but, tentatively, and from the clearest examinations we could make, we form the following geological history of this locality.

1. The granite in the hills and ridges was forced up through Jurassic period and later rocks and it upturned to nearly vertical the superimposed strata, in some of which strata were discovered moulds of silica (lined with small crystals of quartz) like the Trigonia Conradi, also others like moulds of Tancredia Warreniana.

The fissures, also the dykes of diorite, appear to have resulted from disturbances occurring in epochs Post-Oolitic, but not extending later than the Cretaceous, this being the latest known or generally recognized time or period during which gold has been conveyed in large quantities or percentages, as a constituent in granites and diorites, up to the earth's crust; these auriferous granites and diorites are certainly abundant in this region and are not Palæozoic nor Cenozoic rocks. The gold in the reefs or lodes has been dissolved from the granites and diorite rocks by hot mineralized waters and deposited therefrom into the fissures or reefs, on cooling or on deoxidation of the solutions, either enclosed in pyrites or as free gold.

The gold in the placer mines, drifts or leads, appears to have been dérived almost entirely from the disintegrated and denuded granites forming the mountains and from the reefs in the mountains; a small percentage of the alluvial gold is, however, from the small areas or patches of auriferous quartz eroded from the moutonnéd ridges, also a small percentage of gold has been deposited from passing alkaline waters that contain gold in solution.[5,6]

The patches of auriferous quartz found generally at the base of the moutonnéd ridges as if eroded from them appear to have been transported (with the other materials composing the moutonnéd ridges) from auriferous reefs in the ridges forming the southeastern part of the Matagalpa system of mountains.

The boulders of bluish-colored rocks, auriferous and containing a large percentage of pyrites, found quite frequently in that region, are usually some variety of the soda-bearing hornblede rocks like glaucophanyte, although bluish trachytes, also bluish hypersthene boulders, some of them auriferous (probably all of them) were discovered. Some of the very interesting observations noted were: (*a*) The altitude above the Caribbean Sea (aneroid readings) of several of the hills and ridges in the region herein described is from 1,000 to 3,600 feet, consequently the flow of water to the Caribbean Sea, only 90 or 100 miles distant, is very rapid, there being no swamps, only those of brackish water in the delta of the rivers; this rapid descent of water from the mountains over numerous rapids, cascades and falls in the creeks and rivers offers many places where great water power or pressure could be had to move machinery for sawing logs, defibrenating plants, mining, etc.; (*b*) That region, excepting the clay-surfaced moutonnéd ridges, is covered, from two to twelve or more feet deep, with a very fertile soil composed in large percentage of partly decomposed vegetable matter (nitrogenous) and potash and other alkalies and alkaline earths, from the alkali-containing rocks, granite, feldspar, etc. Consequently there are excellent agricultural lands for corn, potatoes, coffee, tobacco, almonds, etc., on the sides of the hills and ridges, and suitable for sugar cane, plantains, bananas, cacao, India rubber trees, etc., in the valleys. Some of the mountain lands are admirable for coffee, and in the upper valley lands, indigenous cacao trees (Theobroma) of good varieties are numerous; (*c*) The climate is warm, but not uncomfortable, no lagoons nor swamps in the hilly region; (*d*) On the mountain ridges grow forests of large trees, among which mahogany, cedar, rosewood, sapote (Ulva sylvestra), iron wood, guanacaste and nispero appear to be the most numerous.

The tunoo trees[7] are also numerous and of large size, and, young vigorous-growing India rubber trees (Syphonia elasticos) are very abandant, while in shaded moist places, the surfaces of disintegrating rocks are frequently covered with the beautiful velvet vine of Nicarragua (first discovered about 1856 in Nicaragua), having

[5]Gold being invariably found in the granitic series of rocks, especially those of Palæozoic and Mesozoic eras and early Tertiary period, should, I am inclined to believe, influence us to recognize the gold as a constituent and not merely an accessory mineral in the rock.

[6]The fact of the existence of gold in rocks of the granitic series appears to give support to the theory of the successional [illegible] elements in the [illegible] of greatest sp. gravity being nearest to the earth's centre. Platinum, gold and iron appear to have been brought to the crust of the earth in every upheaval of granitic masma.

[7]The tunoo exudes freely, when scarified, a milky juice appearing like the milk or sap that flows from lacerations in an India rubber tree, but concretes into a gum like gutta percha. The fibrous inner bark is a texture of strong interwoven fibres and can be removed from the tree in pieces as wide as the circumference of the tree (from three to six or six and a half feet wide) and twenty to forty feet long. The Soomoos and Sambos use this bark as bedclothing and as clothing for their bodies; they prepare the bark for these purposes after removing it from the tree by wetting in water and softening by beating it with sticks, when it becomes soft and remains very strong.

its exteriorly pure, white, trumpet-shaped, velvety flower tinted with various clear colors of purple, golden, pink, etc. Orchids in great variety are numerous, also ferns of all sizes, up to trees twenty feet high, are abundant.

This wilderness contains much undeveloped wealth in its export varieties of trees, medicinal and fibrous plants, and in its undeveloped minerals, metals, and very fertile agricultural lands, and has much to interest scientists, especially naturalists.

July 30.

A NEW REFLECTING AND DIRECT ACTING POLARISCOPE FOR THE ARC LIGHT PROJECTOR.

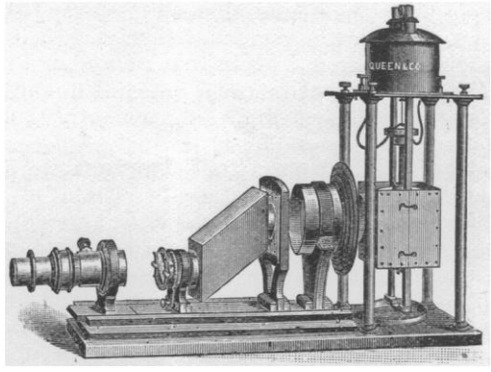
BY OSCAR KNIPE, PHILADELPHIA.

REFERRING to a paper on the subject of Projection, published lately in *Engineering* and several other periodicals, it was then indicated that most of the accessory instruments for Projection, among them the polariscope, would become more popular and find increased employment in the various courses of instruction. The arc light being so convenient, prompt in application and so perfectly satisfactory, suggests, of course, an extended application, and in consequence the expert will frequently find chances for improvement.

The favorite construction of the polariscope has been with Nichol's Prisms, two of these being employed, one for the polarizer and the other for the analyzer. To obtain brilliant effects it is necessary that the former should be at least two inches across the face; unfortunately it is now impossible to obtain such large crystals of spar, and as the demand for these instruments increases very much the reflecting polariscope again comes to the front; the old elbow arrangement furnished by some makers of instruments is a very clumsy attachment and inconvenient, as it requires the projector to be turned side-ways so that the light can reach the screen in front of the audience.

Various modifications have been proposed mainly by London makers and amateurs to obtain a direct acting reflecting polariscope by two opposite surfaces set in a box at the usual angle and deflecting the beam upward or downward, but the main objection, that of being inconvenient, still remained. The optical bench of the Paragon Projector offers, however, special advantages in that respect; the distance from the centre of the arc to the slide base being sufficient to allow a downward polarizer to be adopted, leaving abundant room for the object stage, objective and analyzing prism upon the bench. In practice this instrument is found to be simple in adjustment with the light, and the results obtained are surprising; the field projected is perfectly circular and even, alternating it light and completely dark by rotating the analyzer. The object stage here used is a novel devise; it consists of two uprights which open and close by a spring forming a clamp, a rotating ring with spring clips is secured to each clamp upright, so that three objects can be combined at one time, which is required for circular and eliptic polarization. The stage for exhibiting the phenomena of polarization in crystal, glass forms (verre trempe), and those produced by heating the object will be described at a future time.

The polariscope described above is specially adapted for plane and circular polarization of geometric and fancy designs of Selenite and Mica. The latter is easily obtainable and can be split into laminæ of various thicknesses, the thinnest that can be taken off in a square of about two inches is technically known as an eighth wave plate, the next thickness equal to two one-eighth films superposed is termed a quarter wave film and another equal to two one-quarter films superposed is the half wave film. The quarter and half wave films are the most useful in producing the most marvellous color combinations imaginable, not only in the gay primaries of the solar spectrum, but also in the more quiet grays and plain colors generally; taking a specimen composed of four or six strips of selenite about one-quarter of an inch wide by one and a quarter inches long, laid closely together, it will project its primary colors at once upon the dark field obtained by the position of the analyzer; the slightest turn to the right or to the left produces a change in the colors, but if we move the prism through one-quarter of a revolution the field is changed to a ground flooded with light and the colors have respectively changed to their complementary tint, the carmine has become a pale green, the lemon color an azure blue and so on; they are termed complementary because when superposed they produce white light. Allowing the specimen to remain, we take advantage of the rotary slip in front of our triple object stage and place there another specimen of selenite strips exactly like the first, but place it at right angles or diagonally and we now will have an illustration of the fact alluded to that complementary colors produce white light. The reason that only here and there a square or diagonal of real black or white is produced is found in the difficulty in matching exactly the films. After passing through the various changes, taking a note perhaps of the exact angle at which a certain color is produced so as to be able to repeat it afterward, we will remove the specimen from the front of the stage, and replace it by a quarter wave film; these have generally the axis marked on the edge by an arrow. We shall now obtain a decidedly different set of colors, which con be varied by rotating the analyzer; but notice now that instead of the two complementary colors we have a continual interchange of four or more colors, which can all be registered and repeated. When the quarter wave or half wave film is placed on the rotary clip at the back and rotated we obtain a different set of colors as well as



a colored background. A specimen representing three or four concentric circles, or a wheel divided into a number of sections joining at the centre or again a thin slab of selenite which is ground concave on its face, either of these will give the most beautiful and fascinating changes of color. As these various types of colors are absolute standards taken from the book of nature which can be exhibited precisely alike, it is obvious that we have here in this branch of polariscope study the most brilliant, complete and unchangeable system of color samples with their complementaries and color contrasts which far surpass any book of artificial colors. These when projected on the screen in a class become the objective point of every member, and can be pointed out, and commented upon by the instructor. As the geometric designs may be varied in composition, the mica films being very inexpensive, it requires merely a little patience and experience to produce an unlimited variety. The apparatus described in this article is made by Queen & Co. Incorporated of Philadelphia.